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Anti-inundation measures for underground stations of Tokyo Metro

Yoji Aoki[a,*], Atsushi Yoshizawa[a], Tomoya Taminato[a]

[a]*Tokyo Metro .Co. Ltd, 3-19-6, Higashi-ueno, Taito-ku, Tokyo, Japan*

Abstract

Tokyo Metro Co., Ltd. (hereinafter, Tokyo Metro) comprises nine lines operating over 195.1 km and 179 stations, and is used by 7.07 million passengers per day. Tokyo Metro operates on the belief that security equals safety plus service. In regard to safety, special effort is devoted toward countermeasures for natural disasters. In light of recent extreme weather events, countermeasures for heavy rains are particularly important. It was reported in the updated expectations for flood damage published in 2009 that metropolitan area's 17 lines and 97 stations and 147km of the tunnels will be completely submerged underwater. In response to expectations, we are developing and installing various waterproofing facilities at all tunnel entrances, ventilation openings, underground station entrances and other openings. Among these, underground station entrances are expected to suffer the most damage. Most Tokyo Metro station entrances are situated on sidewalks, there are many obvious spatial restrictions. In light of these restrictions, conventional waterproofing doors (hinged doors that apply positive pressure against floodwater pressure) cannot be used to improve all entrances, thus we have continued to develop counterpressure doors, hinged double doors, shutters, bi-fold doors and other types of waterproofing doors that fit the environments of individual entrances. In addition, few of the many buildings to which Tokyo Metro tunnels connect underground are prepared for the updated expectations for flood damage, meaning that Tokyo Metro must take action on its own property to prevent flood water inundation from such buildings. This means taking flood control measures in underground concourses with severe spatial limitations. Thus, we have developed counterpressure sliding doors capable of withstanding water pressure from flooding up to 15 m deep. This report describes updated expectations for floods, Tokyo Metro's improvement policy and descriptions of various types of underground waterproofing doors and the performance required of them.

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* Corresponding author. Tel.: +81-33-837-7195
E-mail address: yo.aoki@tokyometro.jp

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1. Introduction

Tunnels stretch across 168.6 km (158 stations) of Tokyo Metro subway lines, and roughly 90% of this total length is underground. Recently published updated flood expectations predict major damage to the entire metropolis of Tokyo due to water flowing into tunnel entrances and other openings turning the tunnels into wastewater pipes. Most concerning is water flooding into entrances, and a pressing challenge is to find flood control measures for both Tokyo Metro entrances as well as those from adjacent buildings ("petition entrances").

Our assumptions are based on a tsunami simulation for the Tokyo Metropolitan area, in the case of a vertical shock earthquake (Tokyo Bay northern earthquake M7.3) and a trench type earthquake (Genroku type Kanto earthquake M8.2 and Nankai-trough earthquake M9). These simulations assume that a tsunami would not breach the existing Tokyo Bay embankment.

2. Existing Tokyo Metro Flood Control Measures

As measures against the flooding of roads by overflowing rivers, typhoons or sudden rains, Tokyo Metro has long installed water stop plates (Figure 1 shows one that is 750 mm tall) at entrances and flood preventing machines (Figure 2 show one that works for flooding up to 2 m) at ventilation openings in lowlands and depressions, as well as watertight gates (Figure 3) at some tunnel openings near lowlands and rivers. We have installed tide gates (Figure 4 shows a positive-pressure waterproofing door) at station entrances as a measure against storm surges in sea-level areas.

In addition to these flood control measures, sump pumps discharge rainwater and other water that flows into tunnels.

Fig. 1. Water Stop Plate.

Fig. 2. Flood Fig.

Fig. 3. Watertight Gate.

Fig. 4. Outward Waterproofing Door.

3. Updated Expectations for Damage of Major flooding (collapse of levees on the Arakawa/Tonegawa Rivers)

In January 2009, the Central Disaster Management Council (a Japanese cabinet committee) published a report of expected damage, in the event of a collapse of the Arakawa River levees. There are 2 scenarios, first with heavy rain that could be expected to occur once in 200 years (550 mm^3 per day) and second with severely heavy rain expected to occur once in 1,000 years (638 mm^3 per day). These predictions showed flood damage reaching central Tokyo and submerging most subway stations. Specifically, 17 lines, 97 stations and 147 km of tunnels in Tokyo would flood, and floodwaters would inundate central Tokyo around three hours after a levee collapse, putting Otemachi Station under as much as 1.8m of water (hereinafter Major flood). Figure 5-1 is a simulation of flooding 72 hours after the collapse of an Arakawa River levee in the 1,000-year case.

In addition, heavy rain in the Tokai region (September 2000, 534 mm^3 in 24 hours) prompted city administrators to publish hazard maps that expected depth of inundation in depressions due to the overflow of small and medium-sized rivers during sudden rains and other flood events(Figure5-2). (hereinafter Urban flooding).